Original Research Article

Mitigate climate change impact: Maximizing the tolerance of eggplant to salinity stress using selenium supplements

Abstract

Sea level rise (SLR) is one of the most risky climate change impacts under Egyptian conditions ~~through increasing~~ the salinity of northern Delta. Increasing the tolerance for salinity in current and future ~~varieties~~ is strongly desirable. The current experiment was carried out in the experimental station at Agriculture Research Center, Egypt, during the summer seasons of 2014 and 2015, to evaluate the effect of selenium foliar applications (0, 5, 10, 20, 30 µM Na_2SeO_3) on eggplant ~~characteristics (vegetative growth, yield, proline and some elements content)~~ grown on a sandy soil and irrigated with different concentrations of saline water (0, 30, 60, 120 mM Na Cl). ~~Observed~~ results showed that the Se supplement with 20 µM showed the best effects on vegetative growth and yield of eggplants under different salinity levels of irrigation water, with the highest effect at 0 mM Na Cl irrigation treatment and decreased with increasing salinity of such irrigation water (from 30 to 120 mM Na Cl). Increasing salinity resulted in increasing N and P contents in the leaves and fruits of eggplant, but K decreased as a result of some sort of antagonism with Na; in spite of that, N, P and K contents in leaves and fruits increased with increasing Se supplements up to 20 µM to be at higher concentrations then decreased. K/Na ratio in leaves decreased with increasing salinity level of irrigation water, but generally increased with increasing Se supplements. The treatment of EC_e 13.5 dS m^{-1} without Se supplements gave the lowest value of K/Na ratio (0.52); treatment of Se 30 µM under 0 mM Na Cl irrigation water gave the highest one (1.71). Also, the results showed that the chlorophyll ~~content~~ in plant leaves increased with increasing salinity level of irrigation water, but decreased with increasing Se supplements, with significant decrease in the treatment of Se 20 µM under conditions of 0 mM Na Cl irrigating water. Regarding to the proline ~~content~~ in fresh leaves, ~~the results showed increases~~ with increasing salinity of irrigation water ~~(indication of stress),~~ but decreased with increasing Se supplements as compared to the control. The treatment of EC_e 13.5 dS m^{-1} without Se supplements gave the highest value of proline content (51 mg g^{-1}), ~~with treatment of Se 10 µM under 0 mM Na Cl irrigation water being the lowest one (29.9 mg g^{-1}).~~

Keywords: *Sea level rise, Salinity stress, Selenium supplements, Eggplant, proline content.*

1. Introduction

Egypt is very dependent on natural resources that are vulnerable to climate change. A large portion of the arable land ~~is~~ in ~~the~~ Nile Delta is particularly exposed to sea level rise. ~~Agriculture activities use mainly Nile water, for irrigation, which is opened to precipitation and temperature changes within the entire Nile basin.~~ **Nicholls and Leatherman (1995)** estimated a mean value of 1 meter global sea level rise by the year of 2100 which would give rise to a 0.37 meter sea level rise at the Nile delta. This, combined with a non climate induced subsidence of the Nile Delta of 0.38 meters would result in the movement of the shoreline to the current 0.75 meter contour and a 5 percent loss of Egyptian agricultural land by the year of 2060 mainly at the coastal area of Nile Delta. ~~Agriculture below an elevation of one meter is very difficult due to salinization and seawater intrusion and requires careful water management~~ **(Rosenzweig and Hillel, 1994)**. **El-Raey *et al.* (1995)** suggested land losses of 12 to 15 percent of Egypt's current arable land for a one meter sea level rise.

Salinity is an abiotic stress ~~factor that limits~~ plant ~~development~~ **(Sengupta and Majumder, 2009)**, and ~~it~~ is becoming a serious agricultural problem, especially ~~in irrigated lands located~~ at arid and semi-arid zones, where 20-30% of the land is seriously damaged by salt **(FAO, 2002)**. High salt concentrations in the soil drastically reduce the yields of a variety of plants worldwide **(Gorai and Neffati, 2007)**. ~~In Egypt, it is necessary to use its natural resources of water at the optimum level due to its shortage and increasing the population. One of the main water resources is saline and drainage water, some being of rather good quality under some conditions. However, most of saline and drainage waters cause degradation of the soil and adversely affect plant production **(Abd-Elrahman, 2013)**~~.

Eggplant (*Solanum melongena* L.) is a traditional vegetable ~~crop~~ in many tropical, subtropical and Mediterranean countries. ~~Conflicting literature exist on eggplant tolerance to soil salinity. For example,~~ eggplant is classified as a moderately sensitive vegetable ~~crop~~ **(Maas, 1984** and **Heuer *et al.*, 1986)**; **Bresler *et al.* (1982)**, on the other hand, classified it as salt sensitive vegetable. This difference in its tolerance classification could be related to differences in used varieties or cultivars and ~~to the different~~ environmental conditions ~~of those studies~~. **Unlukara *et al.* (2010)** ~~investigated impacts of salinity on eggplant and~~ found a threshold value lower than 1.5 dS m^{-1} and a slope value of 4.4%. Such authors also reported a decrease in plant water consumption due to salinity with a decrease slope of 2.1%.

Proline ~~accumulates~~ in many plant species under a broad range of stress ~~conditions~~ such as water shortage, salinity, extreme temperatures and high light intensity. Proline is considered to be a compatible solute. It protects folded protein structures against denaturation, stabilizes cell membranes by interacting with phospholipids, functions as a hydroxyl radical scavenger and serves as an energy and nitrogen source. ~~In some plant species, proline plays a major role in osmotic adjustment such as in potato **(Büssis and Heincke, 1998)**; in others, such as in~~

~~tomato **(Pérez-Alfocea *et al.*, 1993)** proline accounts for only a small fraction of the total concentration of osmotically active solutes. Therefore, its contribution~~ to osmotic adjustment and tolerance of plants exposed to unfavourable environmental conditions is still controversial **(Hare and Cress, 1997)**. The metabolic effects of osmolyte accumulation may, however, be equal or even more important than their role in osmotic adjustment, since stress-regulated changes in proline synthesis and degradation may also affect expression of other genes, ensuring that the genetic response to stress is appropriate to the prevailing environmental stress conditions **(Claussen, 2005)**. ~~Proline accumulates under salt stress in both leaf and root tissues **(Aziz *et al.*, 1999)** and protects against the osmotic potential generated by salt **(Chen *et al.*, 2007)**~~.

Although selenium (Se) is not considered an essential nutrient for plant growth, it is a vital element for human and animal nutrition in trace amounts **(Terry *et al.*, 2000)**. However, a diet containing 1 mg kg^{-1} dry weight (DW) ~~Se~~ may lead to chronic Se poisoning in humans and animals, and one-time ingestion of plant material containing 1,000 mg kg^{-1} DW ~~Se~~ can lead to acute Se poisoning and death **(Pilon-Smits and Quinn, 2010)**. Selenium is a constituent of seleno-proteins, many of which have important functions, including antioxidant protection, energy metabolism and redox regulation during transcription and gene expression **(Kong *et al.*, 2005)**. ~~Small concentrations of Se can increase the level of tolerance of plants against oxidative stress **(Abd El-Nasser *et al.*, 2010)**~~. Selenium supplementation to plants enhance the production and quality of edible plant products, by increasing antioxidant activity of plants, as shown in tea leaves **(Xu *et al.*, 2003)**, and ~~in~~ rice **(Xu and Hu, 2004)**. ~~Spraying plants with selenium solution may enrich the utilizable plant parts with Se compounds in concentrations of nutritional importance **(Yassen *et al.*, 2011)**~~. Foliar application of selenium was shown to be several times more efficient than application in fertilizers **(Aspila, 2005)**, but ~~riskier as Se uptake by the crop depends~~ on spraying conditions. **Curtin *et al.* (2006)** also showed that foliar spray gave a high recovery. However, **Lyons *et al.* (2004)** found foliar application to be less efficient than application to soil at planting.

Thus, the main objective of this study is to evaluate the protective effect by foliar application of selenium supplements (0, 5, 10, 20, 30 µM Na_2SeO_3) on eggplant ~~characteristics~~ (vegetative growth, yield, proline and some elements content) grown on a sandy soil and irrigated with different concentrations of saline water (0, 30, 60, 120 mM Na Cl).

2. Materials and Methods

The current experiment was carried out in the experimental station at the Central Laboratory for Agricultural Climate (CLAC), Agriculture Research Center (ARC), Egypt, during the summer seasons of 2014 and 2015.

2.1 Plant material

Eggplant (*Solanum melongena* L. cv. Baladi) seeds were sown on 20th and 18th January of 2014 and 2015, respectively, in polystyrene trays. After the fifth true leaf stage (26th and 23rd February, respectively), the eggplant seedlings were transplanted into bedding system of sandy soil.

2.2 System materials

Open system of sandy soil from Siwa oasis - Matroh governorate, ***Typic Torripsamments***, ~~(some physical and chemical characteristics of the studied soil are shown in **Table 1**)~~ was used ~~under the study~~. The system bed performed of bricks on cement base (60cm width x 25cm height x 7.5m length). The final plant spacing was 50cm in the row and 40cm in-between. Black polyethylene (1mm) was used to create the main gully which was filled by the soil. A layer of 2-3cm of gravel takes a place in the bottom of gully bin for leaching the drainage water easily.

No organic matter or manure was applied to the soil to avoid the effect of organic matter on the salinity impacts under the investigated different treatments.

Different salinity irrigation water levels were pumped via submersible pump (110 watt). A plastic tank 120 L (one per each bin system) and submersible pump (one per each tank) were used to pump the nutrient solution and different salinity irrigation water levels via polyethylene pipe (16mm) with 2 liters per hour dripper. The nutrient solution **(El-Behairy, 1994)** was adjusted by using EC meter to the required level (2.5 dS m^{-1}) in all treatments. The fertigation was programmed to work 2 - 4 times/day and the duration of irrigation time depended upon the season.

Table 1. Some physical and chemical characteristics of the studied soil.

Particle size distribution, %		Soluble cations, meq L^{-1}	
Sand	97.5	Ca^{2+}	3.40
Silt	1.50	Mg^{2+}	3.50
Clay	1.00	Na^{+}	1.50
Texture class	Sandy	K^{+}	0.60
$CaCO_3$, %	5.80	Soluble anions, meq L^{-1}	
OM, %	0.05	CO_3^{2-}	0.00
CEC, cmolc kg^{-1}	9.30	HCO_3^{2-}	3.20
pH (1:2.5 soil:water suspension)	8.19	Cl^{-}	4.10
ECe, dS m^{-1}	0.90	SO_4^{2-}	1.70

2.3 Investigated treatments

The application of different treatments, after 2 weeks of transferring the eggplant seedlings, was applied. The study investigated the effect of different selenium (Se) concentrations (0, 5, 10, 20, 30 µM Na_2SeO_3) as foliar application on eggplant cultivated under different saline irrigation water levels (0, 30, 60, 120 mM Na Cl) on the studied soil.

The EC_w concentrations and Se supplements were applied according to **Nowak, 2009**; **Yao *et al.*, 2009**; **Chu *et al.*, 2010** and **Yassen *et al.*, 2011**.

Eggplants were harvested on 26th and 17th June 2014 and 2015, respectively, prepared and kept for the determination.

2.4 Experiment design

The experimental design was a split plot with 3 replicates. Each experimental plot contained 10 plants. The saline irrigation levels were assigned as main plots and Se concentrations as subplots as **Fig. 1** illustrates.

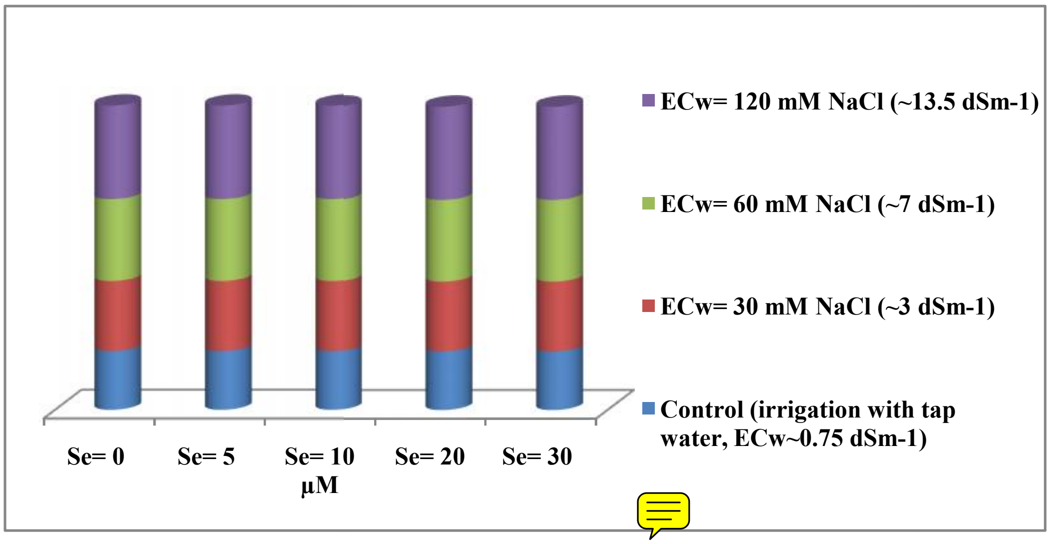


Fig. 1. The layout of experimental design

2.5 Measurements

The vegetative~~,~~ yield characteristics ~~beside~~ the chemical analysis of eggplants were measured as follows:

- Plant height (cm), before starting the flowering stage
- Number of leaves per plant, before starting the flowering stage
- Fresh weight of total fruits per plant (g/plant)
- Number of fruits per plant
- Chlorophyll content in leaves, SPAD:

Total chlorophyll of the fifth mature leaf from top was measured using Minolta chlorophyll meter Spad-501.

- Proline content in 0.5 g of fresh leaves, at harvest:

Proline content was determined according to the method of **Troll and Lindsley (1955)** modified by **Petters *et al.* (1997)**. The proline content was expressed as mg g^{-1} fresh weight (FW).

- Total N, P, K and Na contents in leaves and fruits, at harvest:

Total nitrogen in plant was determined as described by **Chapman and Pratt (1961)**; total phosphorus was determined using spectrophotometer according to **Watanabe and Olsen (1965)** and both total potassium and sodium in plant were determined as described by **Jackson (1958)**.

Statistical analysis was performed using the analysis of variance adopting a SAS software package **(SAS Institute, 1996)**. Significance among treatments was evaluated using Duncan's approach ($P \leq 0.05$), ~~means within and among treatments being used~~.

3. Results and Discussion

3.1 Vegetative growth and yield of eggplants

Data in **Table 2** showed that the plant height was different under ~~effects of designed~~ treatments. ~~Regarding to the irrigation water salinity treatments, the plant heights decreased with increasing water salinity~~. However, the plant height increased with increasing Se supplements. Regarding to the interaction between irrigation water salinity and Se supplements, the irrigation with tap water and Se 20 µM were found to give the highest plant; the irrigation water with EC_e 13.5 dSm^{-1} and Se 0 µM gave the lowest one. ~~Also, number of leaves per plant went hand by hand with the previous findings on the plant height.~~

The total fruit fresh weight and number of fruits per plant were ~~also evaluated (Table 2)~~ ~~and~~ agreed with the ~~previous~~ findings on the plant height and number of leaves per plant. Generally, the Se supplement with 20 µM showed the best effects on vegetative growth and yield of eggplants under different irrigation water salinity treatments, with higher effect for irrigation with tap water and decreased with increasing salinity in irrigation water. These findings may be due to: (1) Se 20 µM is the adequate concentration to be used to counter act salinity problems inside the plant, and less than it considered not enough, where higher than it considered toxic to the plant. (2) The vegetative growth and yield of eggplants decreased with increasing salinity in irrigation water. **Kabata-Pendias and Pendias (1992)** mentioned that Se at 10 ppm DW is considered as phytotoxic. **Terry *et al.* (2000)** found that there was a small decrease in shoot accumulation of Se with increasing salt level. **Unlukara *et al.* (2010)** added that vegetative dry weight of the eggplants decreased with increasing soil salinity and with fruit yield being more sensitive.

Table 2. Effect of irrigation water salinity and selenium supplements on average vegetative growth and yield of eggplants during the two studied seasons.

Treatments	Se 0	Se 5	Se 10 µM	Se 20	Se 30	**Mean**
			Plant height, cm			
EC_w= 0.75 dS m^{-1}	55.2 g	59.7 d	62.1 c	71.7 a	65.0 b	**62.7 A**
EC_w= 3 dS m^{-1}	52.3 h	57.0 f	61.2 c	64.7 b	61.3 c	**59.3 B**
EC_w= 7 dS m^{-1}	45.3 j	49.7 i	58.0 e	60.3 cd	58.0 e	**54.3 C**
EC_w= 13.5 dS m^{-1}	35.0 l	43.7 k	45.7 j	56.0 g	52.7 h	**46.6 D**
Mean	**47.0 D**	**52.5 C**	**56.7 B**	**63.2 A**	**59.3 B**	
			No. of leaves/plant			
EC_w= 0.75 dS m^{-1}	68.3 i	72.8 h	84.0 f	128 a	113 b	**93.2 A**
EC_w= 3 dS m^{-1}	62.7 k	72.0 h	76.7 g	98.3 d	101 c	**82.1 B**
EC_w= 7 dS m^{-1}	60.3 l	63.7 k	67.7 i	100 c	87.0 e	**75.7 C**
EC_w= 13.5 dS m^{-1}	59.3 l	63.3 k	66.3 j	83.0 f	72.3 h	**68.9 D**
Mean	**62.7 E**	**68.0 D**	**73.7 C**	**102 A**	**93.3 B**	
			Fruit fresh weight, g/plant			
EC_w= 0.75 dS m^{-1}	1149 e	1222 d	1342 c	1686 a	1475 b	**1375 A**
EC_w= 3 dS m^{-1}	748 h	880 g	1019 f	1125 e	1036 f	**962 B**
EC_w= 7 dS m^{-1}	517 k	597 j	675 i	850 g	734 h	**675 C**
EC_w= 13.5 dS m^{-1}	356 m	433 l	513 k	573 jk	544 k	**484 D**
Mean	**693 D**	**783 C**	**887 B**	**1058 A**	**947 B**	
			No. of fruits/plant			
EC_w= 0.75 dS m^{-1}	19.5 d	20.0 d	21.0 c	24.4 a	22.0 b	**21.4 A**
EC_w= 3 dS m^{-1}	14.7 h	15.7 g	17.3 f	18.4 e	17.0 f	**16.6 B**
EC_w= 7 dS m^{-1}	11.7 ij	11.8 i	12.3 i	14.7 h	13.8 h	**12.8 C**
EC_w= 13.5 dS m^{-1}	9.15 k	9.60 k	10.8 j	10.8 j	11.2 j	**10.3 D**
Mean	**13.8 C**	**14.3 C**	**15.3 B**	**17.1 A**	**16.0 B**	

3.2 N, P and K contents in leaves and fruits of eggplants

Data in **Table 3** showed the effect of irrigation ~~with~~ saline water on N, P and K contents in leaves of eggplants under Se supplements, ~~compared with the control (without any treatments).~~ Increasing salinity resulted in increased N and P contents in the leaves, but decreased K. Almost, N, P and K contents in leaves increased with increasing Se supplements up to 20 µM Se then decreased with higher concentrations. Regarding to the interaction between irrigation water salinity and Se supplements, Se 20 µM with all saline water treatments generally gave the highest value of N, P and K contents in plant leaves; almost all saline water treatments without Se supplement gave the lowest ones.

Table 3. Effect of irrigation water salinity and selenium supplements on average N, P and K contents of eggplant leaves during the two studied seasons.

Treatments	Se 0	Se 5	Se 10 µM	Se 20	Se 30	**Mean**
			%N			
EC_w= 0.75 dS m^{-1}	2.80 m	3.50 k	3.36 l	4.34 e	3.78 h	**3.56 D**
EC_w= 3 dS m^{-1}	3.78 h	3.76 h	3.64 j	4.48 d	3.99 g	**3.93 C**
EC_w= 7 dS m^{-1}	4.48 d	4.90 c	3.69 i	4.90 c	4.01 g	**4.40 B**
EC_w= 13.5 dS m^{-1}	5.88 a	4.94 c	4.90 c	5.32 b	4.20 f	**5.05 A**
Mean	**4.24 B**	**4.28 B**	**3.90 C**	**4.76 A**	**4.00 C**	
			%P			
EC_w= 0.75 dS m^{-1}	0.61 h	0.62 h	0.65 g	0.70 f	0.65 g	**0.65 C**
EC_w= 3 dS m^{-1}	0.64 g	0.67 f	0.69 f	0.75 e	0.68 f	**0.69 C**
EC_w= 7 dS m^{-1}	0.69 f	0.74 e	0.79 d	0.82 c	0.76 e	**0.76 B**
EC_w= 13.5 dS m^{-1}	0.81 c	0.86 b	0.87 b	0.93 a	0.86 b	**0.87 A**
Mean	**0.69 D**	**0.72 C**	**0.75 B**	**0.80 A**	**0.74 BC**	
			%K			
EC_w= 0.75 dS m^{-1}	1.62 e	1.81 c	1.94 b	1.84 c	1.70 d	**1.78 A**
EC_w= 3 dS m^{-1}	1.50 g	1.77 c	1.79 c	1.62 e	1.65 e	**1.67 B**
EC_w= 7 dS m^{-1}	1.26 i	1.57 f	1.58 f	2.20 a	1.58 f	**1.64 B**
EC_w= 13.5 dS m^{-1}	1.09 k	1.16 j	1.23 i	1.40 h	1.53 g	**1.28 C**
Mean	**1.37 D**	**1.58 C**	**1.63 B**	**1.77 A**	**1.62 B**	

Regarding to the fruits of eggplant, data in **Table 4** showed the effect of irrigation water salinity on N, P and K contents under Se supplements. ~~The results went hand by hand with that obtained for plant leaves.~~ Increasing N and P contents in leaves and fruits of eggplant with increasing salinity of irrigation water may be due to increase in proline content inside the plant with increasing the stress, as will be mentioned later; proline also interact with phospholipids to adjust the osmotic potential **(Abd El-Nasser *et al.*, 2010)**. Decreasing K content with increasing salinity of irrigation water, on the other hand, may be due to the increase of Na Cl concentration; Na^+ content increased in leaves and fruits indicating that the eggplant (which has a glycophytic reaction) could not control uptake of Na^+ **(Akinci *et al.*, 2004)**. Increasing N, P and K contents in leaves and fruits of eggplant by increasing Se supplements under irrigation with saline water may be, again, due to the role of Se in increasing antioxidant activity of the plant to face the stress.

Table 4. Effect of irrigation water salinity and selenium supplements on average N, P and K contents of eggplant fruits during the two studied seasons.

Treatments	Se 0	Se 5	Se 10 µM	Se 20	Se 30	**Mean**
			%N			
EC_w= 0.75 dS m^{-1}	2.38 k	2.41 k	2.52 j	2.55 j	2.94 g	**2.56 C**
EC_w= 3 dS m^{-1}	2.40 k	2.57 i	2.68 h	3.10 f	2.55 j	**2.66 C**
EC_w= 7 dS m^{-1}	3.50 d	3.08 f	3.06 f	3.22 e	3.61 c	**3.29 B**
EC_w= 13.5 dS m^{-1}	3.96 a	3.94 b	3.10 f	3.50 d	3.94 b	**3.69 A**
Mean	**3.06 D**	**3.00 C**	**2.84 D**	**3.09 B**	**3.26 A**	
			%P			
EC_w= 0.75 dS m^{-1}	0.48 i	0.51 h	0.54 g	0.57 f	0.51 h	**0.52 C**
EC_w= 3 dS m^{-1}	0.55 g	0.60 e	0.62 e	0.68 c	0.65 d	**0.62 C**
EC_w= 7 dS m^{-1}	0.61 e	0.65 d	0.68 c	0.73 b	0.69 c	**0.67 B**
EC_w= 13.5 dS m^{-1}	0.67 c	0.72 b	0.73 b	0.79 a	0.72 b	**0.73 A**
Mean	**0.58 D**	**0.62 C**	**0.64 B**	**0.69 A**	**0.64 BC**	
			%K			
EC_w= 0.75 dS m^{-1}	1.16 i	1.19 i	1.24 g	1.60 b	1.57	**1.35 A**
EC_w= 3 dS m^{-1}	1.11 i	1.14 i	1.23 hi	1.52 c	1.52 c	**1.31 B**
EC_w= 7 dS m^{-1}	1.06 j	1.16 i	1.21 i	1.67 a	1.48 d	**1.32 B**
EC_w= 13.5 dS m^{-1}	0.99 k	1.06 j	1.17 i	1.33 f	1.41 e	**1.19 C**
Mean	**1.08 D**	**1.14 C**	**1.21 B**	**1.53 A**	**1.50 A**	

3.3 Some stress markers in leaves of eggplants

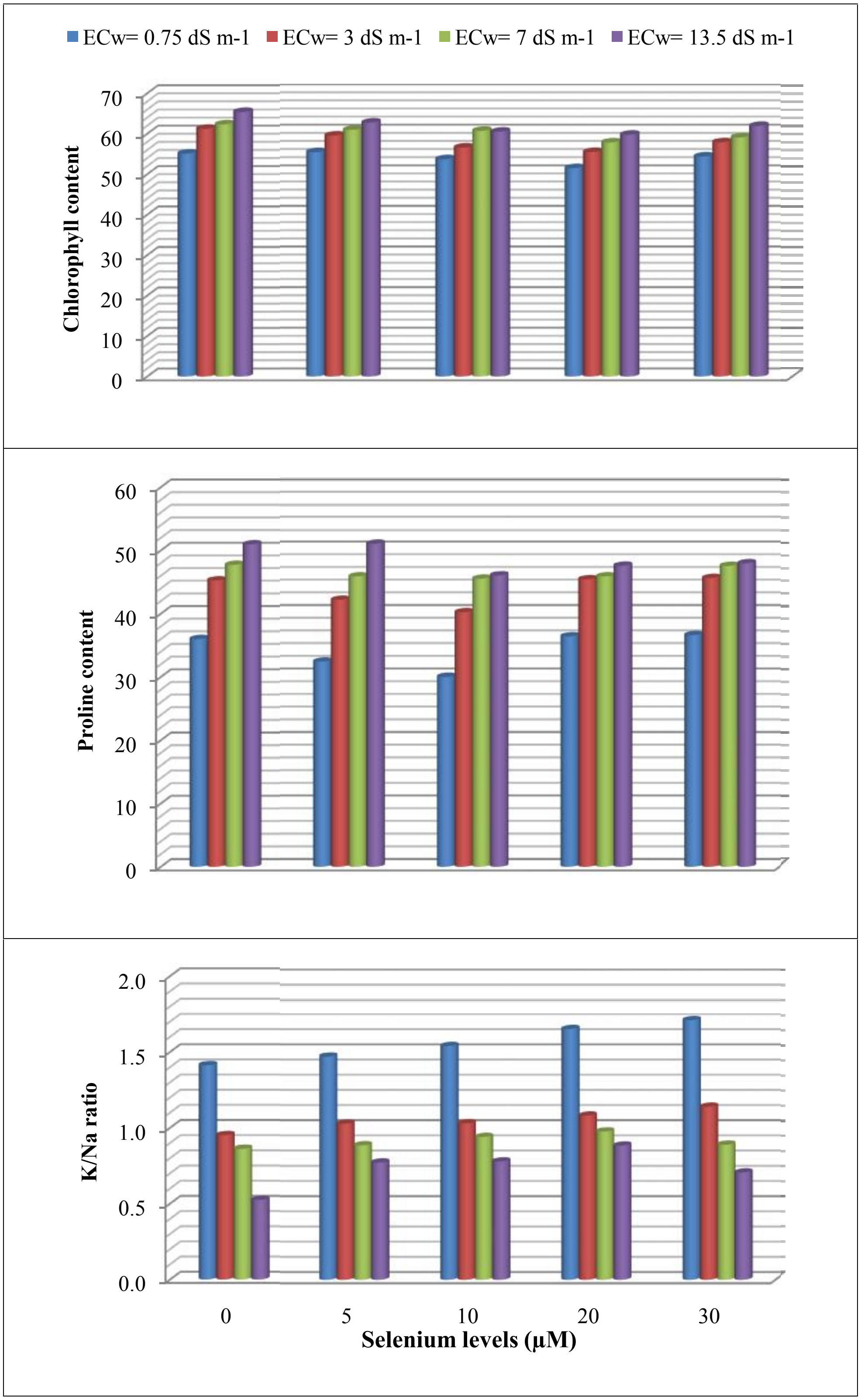
Data in **Table 5** and **Figure 2** showed that chlorophyll content in plant leaves increased with increasing salinity of irrigation water, but decreased with increasing Se supplements, significant decrease in the treatment of Se 20 µM being found under irrigating with tap water. Increasing chlorophyll content in plant leaves indicates that plant suffered from saline stress compared to the control (irrigation with tap water).

Regarding to the proline content in plant fresh leaves, data also showed that proline content increased with increasing salinity of irrigation water (indication of stress), but decreased with increasing Se supplements compared to the control. The treatment of EC_e 13.5 dS m^{-1} without Se supplements gave the highest value of proline content (51 mg g^{-1}), treatment of Se 10 µM under irrigation with tap water being the lowest one (29.9 mg g^{-1}). These findings agreed with those obtained by **Abd El-Nasser *et al.* (2010)** regarding the effect of Se on proline content in cucumber seedlings grown under saline conditions.

Table 5. Effect of irrigation water salinity and selenium supplements on ~~parameter mean of~~ some stress markers in eggplant leaves during the two studied seasons.

Treatments	Se 0	Se 5	Se 10 µM	Se 20	Se 30	**Mean**
			Chlorophyll content, SPAAD			
EC_w= 0.75 dS m^{-1}	55.1 i	55.2 i	53.5 k	51.3 l	54.2 j	**53.9 C**
EC_w= 3 dS m^{-1}	61.2 d	59.3 f	56.4 i	55.3 i	57.7 h	**58.0 C**
EC_w= 7 dS m^{-1}	62.3 b	60.7 e	60.5 e	57.7 h	58.9 g	**60.0 B**
EC_w= 13.5 dS m^{-1}	65.4 a	62.5 b	60.3 e	59.5 f	61.7 c	**61.9 A**
Mean	**61.0 A**	**59.5 B**	**57.7 B**	**56.0 C**	**58.1 B**	
			Proline content, mg g^{-1} FW			
EC_w= 0.75 dS m^{-1}	36.0 l	32.3 m	29.9 n	36.3 k	36.5 j	**34.2 D**
EC_w= 3 dS m^{-1}	45.3 g	42.1 h	40.1 i	45.3 g	45.5 f	**43.6 C**
EC_w= 7 dS m^{-1}	47.7 b	45.7 e	45.4 g	45.7 e	47.4 c	**46.4 B**
EC_w= 13.5 dS m^{-1}	51.0 a	50.9 a	45.9 d	47.4 c	47.8 b	**48.6 A**
Mean	**45.0 A**	**42.8 D**	**40.3 E**	**43.7 C**	**44.3 B**	
			K/Na ratio			
EC_w= 0.75 dS m^{-1}	1.41 e	1.47 d	1.54 c	1.65 b	1.71 a	**1.56 A**
EC_w= 3 dS m^{-1}	0.95 i	1.03 h	1.03 h	1.08 g	1.14 f	**1.05 B**
EC_w= 7 dS m^{-1}	0.86 j	0.88 j	0.94 i	0.98 i	0.89 j	**0.91 C**
EC_w= 13.5 dS m^{-1}	0.52 m	0.77 k	0.78 k	0.88 j	0.71 l	**0.73 D**
Mean	**0.94 E**	**1.04 D**	**1.07 C**	**1.15 A**	**1.11 B**	

Data in **Table 5** and **Figure 2** showed values of K/Na ratio in leaves of eggplants as an important indicator on salinity stress. K/Na ratio decreased with increasing salinity of irrigation water, but increased generally with increasing Se supplements. Regarding to the interaction between irrigation water salinity and Se supplements, the treatment of EC_e 13.5 dS m^{-1} without Se supplements gave the lowest value of K/Na ratio (0.52), the treatment of Se 30 µM under irrigation with tap water being the highest one (1.71). **Akinci *et al.* (2004)** reported that increasing Na Cl in the solution led to a decrease in the K/Na ratio and increased Na in several eggplant varieties.



277 **Fig. 2.** Effect of irrigation water salinity on some stress markers in leaves of eggplant under
278 selenium supplements

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4. Conclusion

Under mitigation and adaption strategy of climate change impacts with the expected increase in the salinity of irrigation water especially in the Northern Egypt as a result of sea level rise, the present study recommends the applying selenium as foliar application at the concentration 10 - 20 µM to increase the tolerance of eggplants against salinity of irrigation water and to avoid salinity stress on the yield.

The real problems of establishing strategy for avoiding salinity impacts on crop production are the slow effect with hidden impact of soil and irrigation water as to become a true crisis. More work is required to investigate the effect of Se on different crops besides studying the impact of sea level rise on the irrigation water and soil salinities.

5. References

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